DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

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BEDROCK GEOLOGIC MAP OF THE NEW JERSEY PARTS OF THE GREENWOOD LAKE AND SLOATSBURG QUADRANGLES SUSSEX, PASSAIC, AND BERGEN COUNTIES, NEW JERSEY
OPEN-FILE MAP OFM 106

by
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INTRODUCTION

The Greenwood Lake and Sloatsburg quadrangles, in northern New Jersey in Sussex, Passaic and Bergen Counties, are situated in the northeastern part of the New Jersey Highlands Physiographic Province. The Wanaque River is the primary drainage in the map area and its impoundment created the Monksville Reservoir, a northern extension of the Wanaque Reservoir system. The topography of the map area is characterized by rugged uplands that include large tracts of land currently undeveloped and managed by the North Jersey District Water Supply Commission, or by the New Jersey Department of Environmental Protection as State Park and Wildlife Management Area lands. East of Greenwood Lake, the topography is dominated by ridges and stream valleys of varied orientation that reflect the structural complexity and non-linear trend of the underlying Mesoproterozoic bedrock. West of Greenwood Lake, and extending to the area of Upper Greenwood Lake, the topography is more linear due to the relatively uniform trend of the underlying Paleozoic bedrock. Northwest of the Paleozoic bedrock, the topography is more varied because of the non-linear trend of the underlying Mesoproterozoic bedrock.

This report provides detailed geologic information on the stratigraphy, structure and description of geologic units in the map area. Cross-section A-A' shows a vertical profile of the geologic units and their structure. Rose diagrams in figures 1-4 provide a directional analysis of selected structural features. The interpretations presented here supersede those shown on previous bedrock geologic maps of the area.

STRATIGRAPHY
Paleozoic Rocks

The youngest bedrock in the map area is Silurian and Devonian that crops out on, and along, Bearfort Mountain, in the Green Pond Mountain Region, a northeast-trending block of downfaulted and folded Paleozoic sedimentary rocks that extends through the northwestern part of the area. The Paleozoic formations include the Green Pond Conglomerate, Longwood Shale, Poxono Island, and Berkshire Valley Formations of Silurian-age, and the Connelly Conglomerate, Esopus Formation, Kanouse Sandstone, Cornwall Shale, Bellvale Sandstone and Skunnemunk Conglomerate of Devonian-age. The origin and stratigraphic relationships of these formations were discussed by Darton (1894), Kümmel and Weller (1902), Barnett (1970, 1976), and Herman and Mitchell (1991).

Neoproterozoic Rocks

A single diabase dike about 25 feet wide intrudes Mesoproterozoic rocks along the north shore of Monksville Reservoir, at the southern edge of the Greenwood Lake quadrangle. Its strike length is unknown because it cannot be traced to the north due to the lack of exposure, or to the south because it is beneath the reservoir. The dike strikes nearly due north and dips steeply east. It has sharp contacts and chilled margins against enclosing Mesoproterozoic rocks. The dike correlates spatially and temporally to similar dikes in the Highlands that are interpreted as having been emplaced into a rift-related, extensional tectonic setting at about 600 Ma during breakup of the supercontinent Rodinia (Volkert and Puffer, 1995).

Mesoproterozoic Rocks

Most of the map area is underlain by rocks of Mesoproterozoic age. These include an assemblage of various granites and gneisses, most of which were metamorphosed to granulite facies during the Ottawan phase of the Grenville orogeny at 1045 to 1024 Ma (Volkert and others, 2010). The temperature for this high-grade metamorphism averages 769ºC based on a regional study using calcite-graphite geothermometry (Peck and others, 2006).

The oldest Mesoproterozoic rocks are the Losee Suite (Drake, 1984; Volkert and Drake, 1999) and a thick assemblage of supracrustal metavolcanic and metasedimentary rocks (Volkert, 2004). Calc-alkalic rocks of the Losee Suite include various quartz-rich gneisses mapped as quartz-oligoclase gneiss, biotite-quartz-oligoclase gneiss, hornblende-quartz-plagioclase gneiss, and hypersthene-quartz-plagioclase gneiss; and quartz-poor rock mapped as diorite, and amphibolite formed in a magmatic arc tectonic setting (Volkert, 2004). The Losee Suite yielded sensitive high-resolution ion microprobe (SHRIMP) U-Pb zircon ages of 1282 to 1248 Ma (Volkert and others, 2010). Spatially and temporally associated with the Losee Suite are supracrustal rocks that include potassic feldspar gneiss and amphibolite all of which formed from felsic and mafic volcanic protoliths, respectively, and quartzofeldspathic gneisses and calc-silicate rocks formed from sedimentary protoliths. Supracrustal rocks were deposited in a back-arc basin situated inboard of the Losee arc (Volkert, 2004). Supracrustal volcanic rocks yielded U-Pb SHRIMP zircon ages of 1299 to 1251 Ma (Volkert and others, 2010) that closely overlap the age of the Losee Suite. Amphibolite associated with the Losee Suite is metavolcanic, whereas amphibolite intercalated with the supracrustal gneisses may be metavolcanic or metasedimentary in origin. All variants of amphibolite are undifferentiated on the map.

Hornblende-bearing granite and related rocks of the Byram Intrusive Suite, that comprise part of the Vernon Supersuite (Volkert and Drake, 1998), are abundantly exposed in the map area where they intrude Losee Suite and supracrustal rocks. Byram rocks form a complete differentiation series that includes quartz monzonite, granite, and alaskite, all of which have a distinctive A-type geochemical composition (Volkert and others, 2000). Byram granite in the Newfoundland quadrangle south of the map area, and elsewhere in the western Highlands, yielded U-Pb SHRIMP zircon ages of 1185 to 1182 Ma (Volkert and others, 2010).

The youngest Mesoproterozoic rocks are postorogenic granite pegmatites that are undeformed, contain xenoliths of foliated gneiss, and intrude other Mesoproterozoic rocks in the area as small, tabular to irregular bodies that are discordant to metamorphic foliation. They form bodies too small to be shown on the map. Pegmatites yielded zircon U-Pb ages of 990 to 965 Ma (Volkert and others, 2005).

STRUCTURE
Paleozoic Bedding

Bedding in the Paleozoic formations of the Green Pond Mountain Region is fairly uniform and strikes at an average of N.38ºE. Beds are predominantly overturned and dip steeply southeast and, less commonly, northwest. They range in dip from 53º to 90º and average 70º.

Proterozoic Foliation

Crystallization foliation, formed by the parallel alignment of mineral grains in the Mesoproterozoic rocks, defines the trend of the bedrock. It is an inherited feature from compressional stresses during granulite-facies metamorphism that deformed the rocks between 1045 and 1024 Ma (Volkert and others, 2010). Foliations are varied in strike because of deformation of the rocks during folding, but they are somewhat more uniform in the western part of the area where they strike mainly northeast. Foliations in the Greenwood Lake quadrangle strike N.28ºE. on average (fig. 1) and N.33ºE. in the Sloatsburg quadrangle (fig. 2). Foliations dip mainly southeast and, very locally, northwest except in the hinge areas of folds where they dip north. The dip of all foliations ranges from 7º to 90º and averages 55º.

Folds

Folds in the Paleozoic rocks are dominated by a southwest-plunging northwest-overturned syncline on Bearfort Mountain (Herman and Mitchell, 1991), the axis of which extends along the ridge crest in the Skunnemunk Conglomerate. Both limbs of the fold dip steeply southeast.

Folds that deform Mesoproterozoic rocks originated during the Ottawan phase of the Grenville orogeny. They deform earlier-formed planar metamorphic fabrics and, therefore, postdate the development of crystallization foliation. Characteristic fold styles in the Mesoproterozoic rocks display three principal geometries. The earliest recognized fold phase consists of east-northeast-plunging, upright to northwest-overturned or southeast-overturned antiforms and synforms. These folds are refolded by the more regionally pervasive northeast-plunging, northwest-overturned antiforms and synforms that have north-trending axial surfaces. The axial surfaces of both fold phases are refolded by a third fold phase that consists of northeast-plunging, northwest-overturned antiforms and synforms that have northeast-trending axial surfaces. The overall sequence of folding is interpreted to represent changing vectors of compressive stress that were roughly synchronous with the granulite facies metamorphism. The plunge of all mineral lineations ranges from 5º to 58º (averaging 30º) N.17ºE. to N.76ºE., with most lineations plunging N.45ºE. No lineations or folds plunging southwest were recognized in Mesoproterozoic rocks.

Faults

Northeast-trending faults are common in the map area and they deform Mesoproterozoic and Paleozoic rocks. They include the Reservoir, Union Valley, Greenwood Lake, Green Turtle Pond, Wanaque River, and Ringwood Faults. Deformation includes ductile and brittle features. Brittle deformation fabric consists of breccia, gouge, retrogression of mafic mineral phases, chlorite or epidote-coated fractures or slickensides, and (or) close-spaced fracture cleavage. Ductile deformation fabric consists of mylonite, boudinage and shear folds.

The Reservoir Fault strikes about N.40ºE and varies in dip from steeply northwest to steeply southeast. It places Paleozoic rocks on the hanging wall against Mesoproterozoic rocks on the footwall along most of its length. The fault has undergone multiple reactivations dating from the Proterozoic that indicate normal, right-lateral strike-slip, and reverse movement, but latest movement was normal. The fault is characterized by ductile deformation fabric in the center of the fault zone that is overprinted by a zone of brittle deformation as much as 1,000 feet wide.

The Union Valley Fault and Greenwood Lake Fault were mapped by Herman and Mitchell (1991) on the basis of missing stratigraphic units along strike to the south. Both faults extend along the northwest side of Greenwood Lake. The Union Valley Fault is bounded by Paleozoic rocks on both sides. It strikes N.40ºE on average. and dips southeast at about 50º. The latest movement was reverse (Herman and Mitchell, 1991). The fault is characterized by a zone of brittle fabric of unknown width. The Greenwood Lake Fault places Paleozoic rocks on the footwall against Mesoproterozoic rocks on the hanging wall. It strikes N.40ºE. and dips southeast at about 60º, either merging with, or cut off by the Union Valley Fault in the subsurface. The latest movement was reverse (Herman and Mitchell, 1991). The fault is characterized by a zone of brittle fabric of unknown width.

The Green Turtle Pond Fault was identified in the Greenwood Lake quadrangle by the author during the rehabilitation of the dam at the south end of Green Turtle Pond (now known as Lake Awosting). It has also been recognized along strike to the south in the Wanaque (Volkert, 2011) and Newfoundland quadrangles (Volket and others, 2013). The fault strikes northeast and dips northwest at about 70º. It is cut off on the north by the newly named Wanaque River Fault, and to the south it continues into the Newfoundland quadrangle where it may continue beneath the unconformity in Silurian rocks on Kanouse Mountain. The fault separates Mesoproterozoic rocks on both sides. Latest movement was dip-slip reverse. The fault is characterized by brittle deformation fabric that is about 100 feet wide.

The Wanaque River Fault was first identified by Hotz (1952) and its strike length was doubled during the current mapping. Although not well exposed, except in outcrops along the Wanaque River in the Wanaque Wildlife Management Area, the fault forms a well-defined lineament on aerial photographs. To the east it continues into Orange County, New York, and to the west it is cut off by the Greenwood Lake Fault. The Wanaque River Fault strikes N.70ºE. and dips north at about 80º. It records dip-slip normal movement but also preserves evidence for right-lateral strike-slip movement. It is bounded by Mesoproterozoic rocks on both sides. The fault is characterized by a zone of brittle deformation fabric as much as 200 feet wide.

The newly named Ringwood Fault in the southeastern part of the quadrangle strikes N.45ºE. and dips southeast at about 80º. It continues north into Orange County, New York, and south into the Wanaque quadrangle, although it was not recognized there prior to publication of that map (Volkert, 2011). The fault is bounded by Mesoproterozoic rocks on both sides. It is characterized by brittle deformation fabric about 100 feet wide.

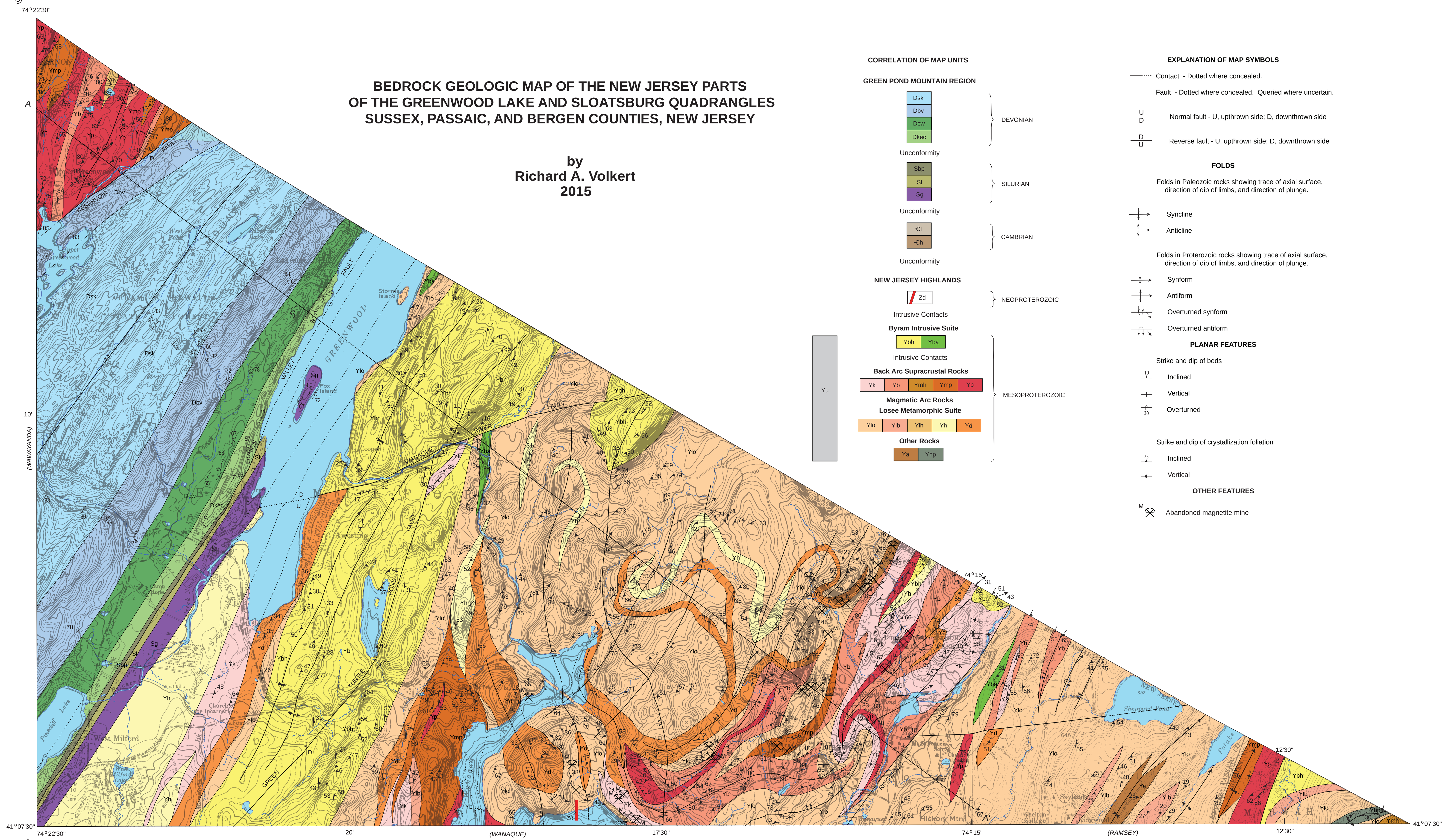
Joints

Joints are a ubiquitous feature in the Paleozoic and Mesoproterozoic rocks but are best developed in massive rocks such as Paleozoic sandstone, quartzite and conglomerate, and in Mesoproterozoic granite and some gneiss. Joints are characteristically planar, moderately well formed, and moderately to steeply dipping. They vary in spacing from a foot to tens of feet apart. Their surfaces are typically unmineralized, except near faults, and are smooth and, less commonly, slightly irregular.

In the Paleozoic rocks, northwest-trending cross joints are the most common. They dip moderately to steeply and nearly equally to the northeast or southwest (Herman and Mitchell, 1991). The dominant joints in Mesoproterozoic rocks are nearly perpendicular to the strike of crystallization foliation, a consistent feature in Mesoproterozoic rocks throughout the Highlands (Volkert, 1996). Therefore, their strike is somewhat varied because of folding. The dominant joints in Mesoproterozoic rocks of the Greenwood Lake quadrangle strike N.52ºW. on average (fig. 3) and dip mainly southwest. A subordinate set strikes about N.20ºE. and dips nearly equally northwest or southeast. The dip of both sets ranges from 50º to 90º and averages 72º. The dominant joints in the Sloatsburg quadrangle strike N.62ºW. on average (fig. 4) and dip mainly southwest. A subordinate set strikes N.35ºE. The dip of both sets ranges from 25º to 90º and averages 67º.

ECONOMIC RESOURCES

Mesoproterozoic rocks in the map area, and particularly those in the Losee Suite, host economic deposits of iron ore (magnetite) that was mined predominantly during the 19th century. Iron mines are widespread throughout the area, but the largest and most important ones are in the southeastern part, in the Ringwood district. Detailed descriptions of most of the mines are given in Bayley (1910), Hotz (1952), and unpublished abandoned mines database of the New Jersey Geological and Water Survey. Exploration for uranium took place during the middle of the 20th century in the northwestern part of the map area, north of Upper Greenwood Lake, on some promising aeroradiometric anomalies, but mining leases were never acquired so no mining occurred. Mesoproterozoic rocks east and south of Greenwood Lake were quarried for crushed stone.



Base maps from U.S. Geological Survey, 1954.

Bedrock geology mapped by R.A. Volkert in 1988, 2007, 2008
Paleozoic geology adopted from Herman and Mitchell (1991)
Digital cartography by M.W. Girard
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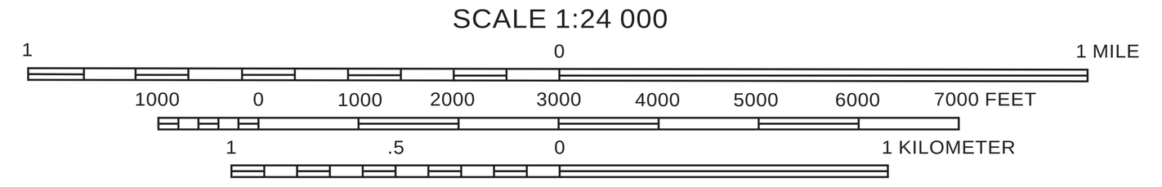
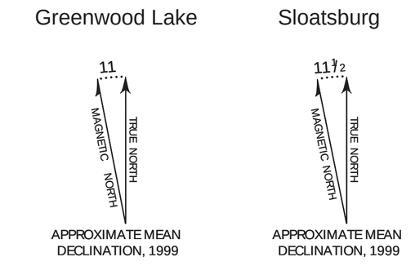
The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

CONTOUR INTERVAL 20 FEET
SCALE 1:24 000



LOCATION IN NEW JERSEY



CORRELATION OF MAP UNITS
GREEN POND MOUNTAIN REGION
Dsk
Dbv
Dcw
Dkec
DEVONIAN
Unconformity
Sbp
Sl
Sg
SILURIAN
Unconformity
€l
€h
CAMBRIAN
Unconformity
NEW JERSEY HIGHLANDS
Zd
NEOPROTEROZOIC
Intrusive Contacts
Byram Intrusive Suite
Ybh
Yba
Intrusive Contacts
Back Arc Supracrustal Rocks
Yk
Yb
Ymh
Ymp
Yp
Magmatic Arc Rocks
Losee Metamorphic Suite
Ylo
Ylb
Ylh
Yh
Yd
Other Rocks
Ya
Yhp
Yu
MESOPROTEROZOIC

EXPLANATION OF MAP SYMBOLS

Contact - Dotted where concealed.

Fault - Dotted where concealed. Queried where uncertain.

Normal fault - U, upthrown side; D, downthrown side

Reverse fault - U, upthrown side; D, downthrown side

FOLDS

Folds in Paleozoic rocks showing trace of axial surface, direction of dip of limbs, and direction of plunge.

Syncline

Anticline

Folds in Proterozoic rocks showing trace of axial surface, direction of dip of limbs, and direction of plunge.

Synform

Antiform

Overturned synform

Overturned antiform

PLANAR FEATURES

Strike and dip of beds

Inclined

Vertical

Overturned

Strike and dip of crystallization foliation

Inclined

Vertical

OTHER FEATURES

Abandoned magnetite mine

DESCRIPTION OF MAP UNITS

GREEN POND MOUNTAIN REGION

Dsk **Skunnemunk Conglomerate (Middle Devonian)** (Darton, 1894) – Grayish-purple to grayish-red, thin- to very thick-bedded, locally cross-bedded, polymictic conglomerate and sandstone containing clasts of white vein quartz, red and green quartzite and sandstone, red and gray chert, and red shale; interbedded with medium-gray, thin-bedded sandstone and greenish-gray and grayish-red, mud-cracked shale. Conglomerate and sandstone matrix is primary hematite and microcrystalline quartz. Conglomerate cobbles are as much as 6.5 in. long, and average cobble size is larger in upper part of unit. Lower contact is conformable and gradational as described by Kümmel and Weller (1902). Unit is about 3,000 ft. thick.

Dbv **Bellvale Sandstone (Middle Devonian)** (Bellvale Flags of Darton, 1894; Willard, 1937) – Upper beds are grayish-red to grayish-purple sandstone containing quartz pebbles as much as 1 in. in diameter. Lower beds are light-olive-gray- to yellowish-gray- and greenish-black-weathering, medium-gray to medium-bluish-gray, very thin to very thick-bedded siltstone and sandstone, crossbedded, graded, and interbedded with black to dark-gray shale. Sandstone more common in upper beds and is finer downward. Lower contact conformable with the Cornwall Shale and placed where beds are thicker and volume of shale and siltstone is about equal. Unit is 1,750 to 2,000 ft. thick.

Dcw **Cornwall Shale (Middle Devonian)** (Hartnagel, 1907) – Black to dark-gray, very thin to thick-bedded, fossiliferous shale, interbedded with medium-gray and light-olive-gray to yellowish-gray, laminated to very thin-bedded siltstone that is more abundant in upper part. Lower contact with Kanouse Sandstone probably conformable. Unit is about 950 ft. thick.

Dkec **Kanouse Sandstone, Esopus Formation and Connelly Conglomerate, undivided (Lower Devonian)**

Kanouse Sandstone (Kümmel, 1908) – Medium-gray, light-brown, and grayish-red, fine to coarse-grained, thin to thick-bedded sandstone and pebble conglomerate. Basal conglomerate is interbedded with siltstone and contains well-sorted, subangular to subrounded, gray and white quartz pebbles less than 0.4 in. long. Lower contact with Esopus Formation gradational. Unit is about 46 ft. thick.

Esopus Formation (Vanuxem, 1842; Boucot, 1959) – Light to dark-gray, laminated to thin-bedded siltstone interbedded with dark-gray to black mudstone, dusky-blue sandstone and siltstone, and yellowish-gray, fossiliferous siltstone and sandstone. Lower contact probably conformable with Connelly Conglomerate. Unit is about 180 ft. thick.

Connelly Conglomerate (Chadwick, 1908) – Grayish-orange-weathering, very light-gray to yellowish-gray, thin-bedded quartz-pebble conglomerate. Quartz pebbles are subrounded to well rounded, well sorted, and as much as 0.8 in. long. Unit is about 36 ft. thick.

Sbp **Berkshire Valley and Poxono Island Formations, undivided (Upper Silurian)**

Berkshire Valley Formation (Barnett, 1970) – Yellowish-gray-weathering, medium-gray to pinkish-gray, very thin to thin-bedded fossiliferous limestone interbedded with gray to greenish-gray calcareous siltstone and silty dolomite, medium-gray to light-gray dolomite conglomerate, and grayish-black thinly laminated shale. Lower contact conformable with Poxono Island Formation. Unit ranges in thickness from 90 to 125 ft.

Poxono Island Formation (White, 1882; Barnett, 1970) – Very thin to medium-bedded sequence of medium-gray, greenish-gray, or yellowish-gray, mud-cracked dolomite; light-green, pitted, medium-grained calcareous sandstone, siltstone, and edgewise conglomerate containing gray dolomite; and quartz-pebble conglomerate containing angular to subangular pebbles as much as 0.8 in. long. Interbedded grayish-green shale at lower contact is transitional into underlying Longwood Shale. Unit ranges in thickness from 160 to 275 ft.

Sl **Longwood Shale (Upper and Middle Silurian)** (Darton, 1894) – Dark reddish-brown, thin to very thick-bedded shale interbedded with cross-bedded, very dark-red, very thin to thin-bedded sandstone and siltstone. Lower contact conformable with Green Pond Conglomerate. Unit is about 330 ft. thick.

Sg **Green Pond Conglomerate (Middle and Lower Silurian)** (Rogers, 1836) – Medium to coarse-grained quartz-pebble conglomerate, quartzitic arkose and orthoquartzite, and thin to thick-bedded reddish-brown siltstone. Grades downward into less abundant gray, very dark red, or grayish-purple, medium to coarse-grained, thin to very thick-bedded pebble to cobble conglomerate containing clasts of red shale, siltstone, sandstone, and chert; yellowish-gray sandstone and chert; dark-gray shale and chert; and white, gray, and pink milky quartz. Quartz cobbles are as much as 4 in. long. Unconformably overlies, or is in fault contact with, Mesoproterozoic rocks. Unit is about 1,000 ft. thick.

€l **Leithsville Formation (Middle and Lower Cambrian)** (Wherry, 1909) – Upper sequence, seldom exposed, is mottled, medium-light- to medium-dark-gray-weathering, medium to medium-dark-gray, fine to medium-grained, medium to thick-bedded, locally pitted and friable dolomite. Middle sequence is grayish-orange or light to dark-gray, grayish-red, light-greenish-gray- or dark-greenish-gray-weathering, fine-grained, thin to medium-bedded dolomite, argillaceous dolomite, dolomitic shale, quartz sandstone, siltstone, and shale. Lower sequence is medium-light- to medium-gray-weathering, medium-gray, fine to medium-grained, thin to medium-bedded dolomite. Quartz-sand lenses occur near lower gradational contact with Hardyston Quartzite. Archaeocyathids of Early Cambrian age are present in formation at Franklin, New Jersey, suggesting an intraformational disconformity between Middle and Early Cambrian time (Palmer and Rozanov, 1967). Unit also contains *Hyolithellus micans* (Offield, 1967; Markewicz, 1968). Ranges from 0 to 185 ft. thick in the map area. Not exposed and shown in cross section only.

€h **Hardyston Quartzite (Lower Cambrian)** (Wolff and Brooks, 1898) – Medium to light-gray, fine to coarse-grained, medium to thick-bedded pebble conglomerate, quartzite, arkosic sandstone and dolomitic sandstone. Conglomerate contains subangular to subrounded white quartz pebbles as much as 1 in. long. Lower contact unconformable with Mesoproterozoic rocks. Contains *Scolithus linearis* (?) and fragments of the trilobite *Olenellus thompsoni* of Early Cambrian age (Nason, 1891; Weller, 1903). Ranges from 0 to 30 ft. thick in the map area. Not exposed and shown in cross section only.

NEW JERSEY HIGHLANDS

Zd **Diabase dikes (Neoproterozoic)** (Volkert and Puffer, 1995) – Light-gray or brownish-gray-weathering, dark greenish-gray, aphanitic to fine-grained dikes that intrude Mesoproterozoic rocks but not Paleozoic rocks. Composed principally of plagioclase (labradorite to andesine), augite, ilmenite and (or) magnetite. Pyrite blebs are common. Contacts are chilled and sharp against enclosing Mesoproterozoic rocks.

Vernon Supersuite (Volkert and Drake, 1998)
Byram Intrusive Suite (Drake, 1984)

Ybh **Hornblende granite (Mesoproterozoic)** – Pinkish-gray or buff-weathering, pinkish-white or light pinkish-gray, medium to coarse-grained, massive, foliated granite composed of mesoperthite, microcline microperthite, quartz, oligoclase, hastingsite, and local zircon, apatite, and magnetite. Grades into alaskite with decrease in amount of hornblende (<5 modal percent). Unit includes bodies of pegmatite too small to be shown on the map.

Yba **Microperthite alaskite (Mesoproterozoic)** – Pinkish-white or buff-weathering, pinkish-white or light pinkish-gray, medium to coarse-grained, massive, moderately foliated rock composed of microcline microperthite, quartz, oligoclase, and local hastingsite, zircon, apatite, and magnetite.

Back-Arc Basin Supracrustal Rocks

Yk **Potassic feldspar gneiss (Mesoproterozoic)** – Light-gray or pinkish-buff-weathering, pinkish-white or light pinkish-gray, medium-grained, massive, moderately foliated gneiss composed of quartz, microcline microperthite, oligoclase, biotite, and magnetite. Garnet and sillimanite occur locally.

Yb **Biotite-quartz-feldspar gneiss (Mesoproterozoic)** – Gray-weathering, locally rusty, gray, tan, or greenish-gray, medium to coarse-grained, moderately layered and foliated gneiss containing microcline microperthite, oligoclase, quartz, biotite, and garnet. Very locally contains sillimanite or kornerupine. Graphite and pyrrhotite are confined to the variant that weathers rusty. Unit is commonly associated with amphibolite and pyroxene gneiss.

Ymh **Hornblende-quartz-feldspar gneiss (Mesoproterozoic)** – Light-gray or pinkish-buff-weathering, pinkish-white or pinkish-gray, medium-grained, foliated gneiss composed of microcline microperthite, quartz, oligoclase, and hornblende. Locally contains biotite, garnet, and magnetite.

Ymp **Clinopyroxene-quartz-feldspar gneiss (Mesoproterozoic)** – Pinkish-gray or pinkish-buff-weathering, white, pale-pinkish-white or light-gray, medium to coarse-grained, moderately foliated gneiss composed of microcline, quartz, oligoclase, clinopyroxene, and trace amounts of titanite, magnetite, biotite, and epidote. Commonly contains conformable layers of amphibolite or pyroxene amphibolite.

Yp **Pyroxene gneiss (Mesoproterozoic)** – White or tan-weathering, greenish-gray, medium-grained, layered and foliated gneiss composed of oligoclase, clinopyroxene, and titanite. Contains varied amounts of quartz. Commonly spatially associated with amphibolite and clots and layers of dark green, medium to coarse-grained rock composed mainly of diopside or hedenbergite too thin to be shown on the map.

Magmatic Arc Rocks
Losee Suite (Drake, 1984; Volkert and Drake, 1999)

Ylo **Quartz-oligoclase gneiss (Mesoproterozoic)** – White-weathering, light greenish-gray, medium to coarse-grained, layered to massive, foliated gneiss composed of oligoclase or andesine, quartz, and varied amounts of hornblende, clinopyroxene, biotite, and magnetite. Locally contains layers of amphibolite too thin to be shown on the map. Unit commonly has gradational contacts with biotite-quartz-oligoclase gneiss, hornblende-quartz-plagioclase gneiss, and hypersthene-quartz-plagioclase gneiss.

Ylb **Biotite-quartz-oligoclase gneiss (Mesoproterozoic)** – Light-gray-weathering, gray or greenish-gray, medium to coarse-grained, layered and foliated gneiss composed of oligoclase or andesine, quartz, biotite, and local garnet. Some outcrops contain hornblende. Locally contains thin, conformable layers of biotite amphibolite.

Ylh **Hornblende-quartz-plagioclase gneiss (Mesoproterozoic)** – White or light-gray- weathering, gray or greenish-gray, medium to coarse-grained, foliated gneiss composed of oligoclase or andesine, quartz, hornblende, and local biotite, clinopyroxene, and magnetite.

Yh **Hypersthene-quartz-plagioclase gneiss (Mesoproterozoic)** – Gray or tan-weathering, greenish-gray or greenish-brown, medium-grained, foliated gneiss composed of andesine or oligoclase, quartz, clinopyroxene, hornblende, hypersthene, and magnetite. Commonly contains thin, conformable layers of amphibolite and quartz-plagioclase gneiss containing hornblende and clinopyroxene.

Yd **Diorite gneiss (Mesoproterozoic)** – Gray or tan-weathering, greenish-gray or greenish-brown, medium to coarse-grained, greasy lustered, massive, moderately foliated rock containing andesine or oligoclase, augite, hornblende, hypersthene, and magnetite. Commonly contains thin mafic layers or schlieren having the composition of amphibolite.

Other Rocks

Ya **Amphibolite (Mesoproterozoic)** – Grayish-black-weathering, black or grayish-black, medium-grained, foliated gneiss composed of hornblende, andesine, and magnetite. Some variants contain biotite and others contain clinopyroxene. Unit is associated with most mesoproterozoic rocks in the map area. Amphibolite interlayered with the Losee Suite is metavolcanic, and that associated with supracrustal rocks may be metavolcanic or metasedimentary. All types are undifferentiated on the map.

Yhp **Hornblende-plagioclase gneiss (Mesoproterozoic)** – White to light-gray-weathering, greenish-gray, medium-grained, foliated gneiss composed of hornblende and plagioclase. Unit is quartz poor. Some outcrops contain trace amounts of biotite and magnetite. Commonly associated with quartz-oligoclase gneiss, but its relationship to the Losee Suite is unknown.

Yu **Mesoproterozoic rocks**, **undifferentiated** – Shown in cross section only.

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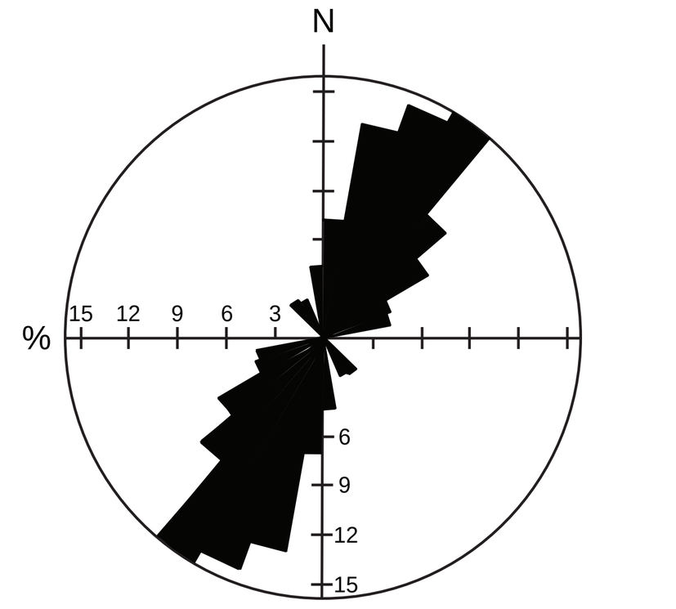


Figure 1. Rose diagram of the strike of crystallization foliations in Mesoproterozoic rocks of the Greenwood Lake quadrangle.

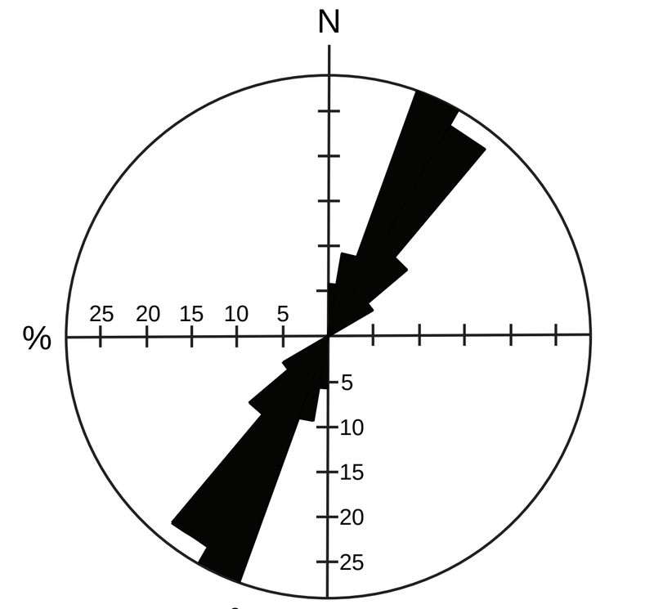
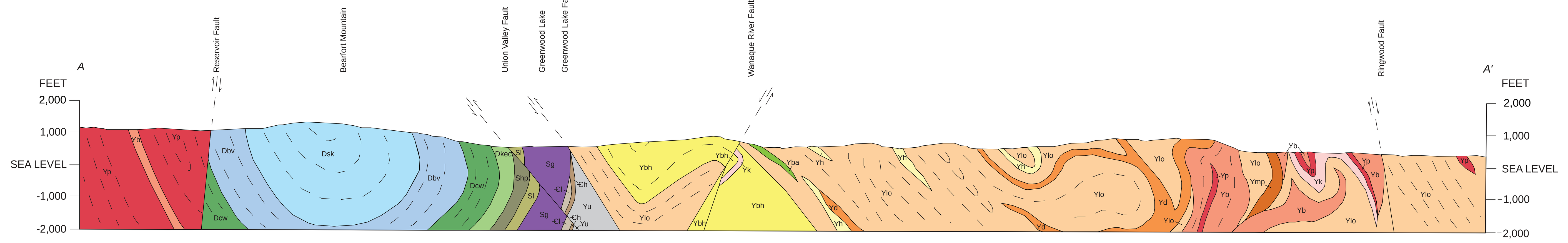


Figure 2. Rose diagram of the strike of crystallization foliations in Mesoproterozoic rocks of the Sloatsburg quadrangle.



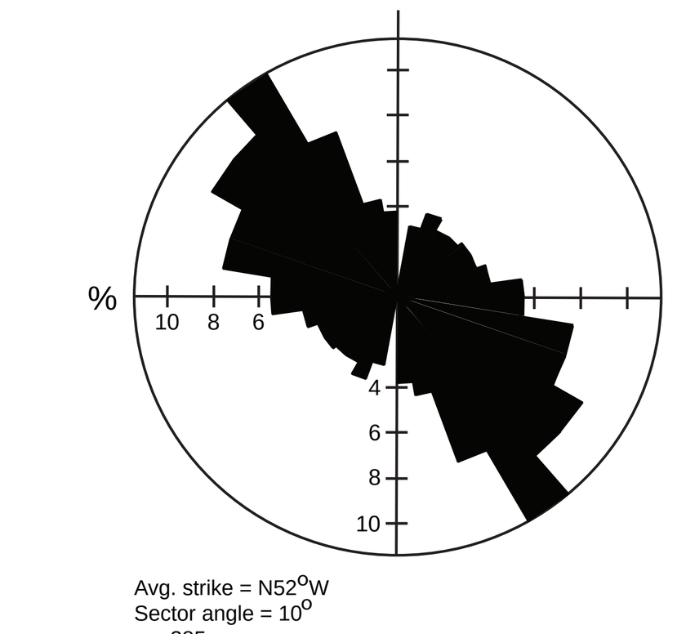


Figure 3. Rose diagram of the strike of joints in Mesoproterozoic rocks of the Greenwood Lake quadrangle.

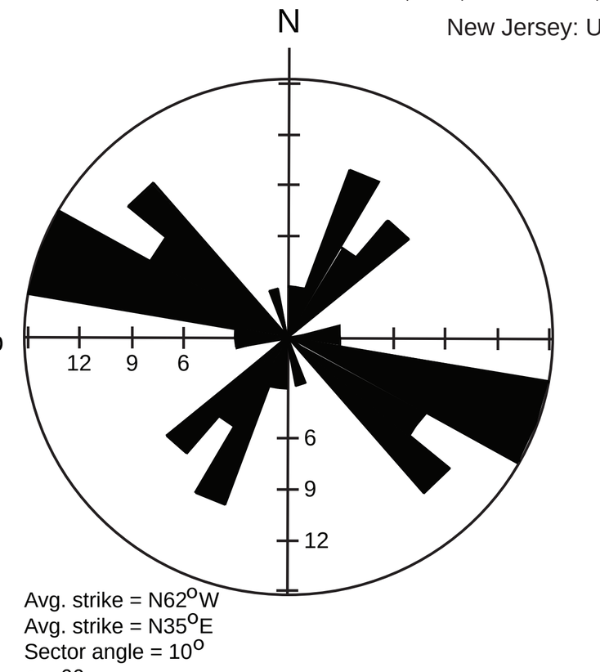


Figure 4. Rose diagram of the strike of joints in Mesoproterozoic rocks of the Sloatsburg quadrangle.